THE IMPACT OF WORKS OF MAN ON THE PHYSICAL REGIME OF BISCAYNE BAY

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ABSTRACT

In 1896 when the City of Miami was founded Biscayne Bay existed in a natural condition much as it had over past centuries. Development began shortly after with the construction of Government Cut, an artificial inlet, and the Miami Ship Channel. The peak of development occurred between 1919 and 1926 with the construction of two causeways and another artificial inlet, Baker's Haulover. By this time the circulation of the Bay was completely altered from its original condition and, in fact, water quality was vastly improved. After a hiatus in development from 1926 to 1946, activities began again on a large scale with the construction of three causeways and a large land fill for the Port of Miami. Although man's impact on North Biscayne Bay has been extremely severe on the biological community, the changes caused by construction of inlets have resulted in a much greater exchange of water between the Bay and the ocean. This benefit has been partially offset by construction of causeways which has decreased and constricted the circulation within the Bay. In 1974 the State Legislature passed a strict law regulating development of the Bay. Future activities will therefore be limited and subjected to careful scientific scrutiny.

INTRODUCTION

In 1896 when the city of Miami was founded, Biscayne Bay existed essentially in a completely natural state. In spite of the fact that the bay may have been affected by human activities since 1100 B.C. as reported by Chardon (in this volume) the import of such a small primitive population on tidal circulation was negligible as compared to what happened in the subsequent 80 years of dynamic growth.

Since changes of major significance have been limited to the northern part of the Bay, the area considered in this presentation will extend generally from Dumfoundling Bay on the north to a line drawn west of the southern tip of Key Biscayne. This discussion will be limited to the effects of those works of man that have actually changed the geometry and thus the hydrodynamic characteristics of the Bay. Discussions of other factors such as the introduction of nutrient and sewage effluent will be covered elsewhere in this volume. Fig. 1 shows a major portion of the area described as it now exists, including all of the development projects discussed.

DISCUSSION

Physical Factors

Biscayne Bay is a shallow estuary separated from the Atlantic Ocean by a chain of spits and islands formed by accretion of the prevailing littoral transport of sand from the north. Interchange of bay and ocean waters is driven by the ocean tide through a series of inlets between the islands and around the south end of Key Biscayne. The ocean tide is semidiurnal, having a mean range of 2.5 feet and a spring range of 3.0 feet (National Ocean Survey, 1974). Swanson (1974) indicates that the mean sea level at Miami Beach has been rising since 1924 at a rate of .012 feet per year (approximately one foot in 80 years). Analysis by Marmer (1951) of earlier records at Baltimore, Md. and New York, N.Y., indicates that this trend has existed along the Atlantic Coast of the U.S. at least since 1893 but at a slightly lower rate.

In understanding the effects of the works of man on an estuary such as Biscayne Bay it is important to understand the effect of the tidal prism on the circulation in the estuary and the exchange of waters with the ocean. The tidal prism is the amount of tidal flow entering and leaving the estuary with each tide. It can be approximated by multiplying the mean surface area of the estuary by the mean tidal range within the estuary.

Since the oceanic water is generally of better quality than that of the estuary, a large tidal prism as compared to the volume of the estuary is desirable from the point of view of water quality. If the surface area or tidal range is increased the tidal prism will increase and decreases in these parameters will cause decreases in the tidal prism. Increases in surface area may be caused by dredging canals or lagoons, decreases are caused by land fill, either in the form of islands or by marginal fills of inundated marsh land. Since the tidal range within the estuary is reduced from that of the ocean by frictional resistance, opening of channels within the estuary or the enlargement of inlets connecting it to the ocean will tend to increase the tidal range.

The portion of Biscayne Bay lying north of Cape Florida presently has a surface area of about 2 billion square feet and a mean tidal range of about 2 feet, giving a tidal prism of about 4 billion cubic feet per tide. By way of comparison, the Miami River which is the principal source of fresh water has an average flow of 701 cubic feet per second which corresponds to .016 billion cubic feet per tide or 1:250th that of the exchange with the Ocean. This shows the great significance of the tidal prism as the driving force of the circulation of Biscayne Bay.

In addition to its effect on circulation, changes in the tidal prism have a considerable effect on the littoral processes along the ocean beaches by way of the inlet. Any inlet interrupts the flow of sand along the beach causing sand to go out to sea and sand to go into the estuary. The more flow through the inlet, the more effective it is as a barrier. Since the net littoral drift in southeast Florida is from north to south, an inlet will tend to cause accretion to its north and starvation of beaches to its south. Inasmuch as the volume of the tidal prism must be carried in and out through the inlets on each tide, its volume will effect the transport of sand, intensifying or alleviating erosion as it increases or decreases.

Biscayne Bay in 1896

In 1896 Biscayne Bay was not much different than it had been for the last few centuries. Its northern portion was extremely shallow with the northernmost inlet being Norris Cut, 13 nautical miles to the south of Dumfoundling Bay. This was then as it is now a shallow inlet with relatively little tidal flow. Approximately one mile further south was Bear Cut which had a substantial cross-section and contributed considerably to the tidal exchange with the Bay. By far the largest portion of the exchange with the Ocean came across the swash channels south of Cape Florida and flowed northward. Although no data on tidal

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One fortunate aspect of the dredging activities during this period is that the borrow areas were no more than 8 to 10 feet deep. This was due to the limited depth capabilities of the dredges used and to their inability to handle hard material. As a result, only a relatively small portion of the Bay could be filled whether the developers liked it or not.

In 1928, with the crash of the stock market, the development boom burst creating a status quo until after the end of World War II in 1945.

The Post War Years (1945-1975)

As soon as construction materials became available after World War II another building boom hit the Miami area. After nearly twenty years of practically no activity, projects began to be developed to accommodate the rising population. One of the first activities to affect the Bay was the construction of the Rickenbacker Causeway between the mainland and Key Biscayne. This causeway, planned prior to World War II, was mostly on fill with two openings: one a short span near the west shore of the Bay, and the other a long span approximately in the center of the Bay. The stretch between these spans was constructed on fill obtained from a borrow pit located just to the north of the Causeway. This pit was dredged to a depth of over 20 feet in places so that it acts as a trap for detritus. In spite of this, the water quality in the pit is good with only the bottom sediment in an anaerobic condition. Since the area was very close to the inlets to the Bay, not much change was caused in the circulation of the lower bay.

In 1951 the Broad Causeway was constructed across the northern part of the Bay. Although most of the solid fill was constructed in shallow water, this causeway restricted the tidal flow enough to reduce the exchange between the Ocean and the Bay north of the 79th Street Causeway. This caused a problem in that flotsam in the vicinity of Miami Shores is not flushed to sea. No significant borrow pits are associated with this structure.

In 1960 construction was begun on a new port for the City of Miami located just south of the Ship Channel. This port which is still under construction is situated on an island created by filling some of the existing spoil islands. At the present time the island contains about 280 acres. It is surrounded by deep channels and turning basins which tend to increase the circulation in the area.

About the same time, the Julia Tuttle Causeway was built across Biscayne Bay between the Venetian and 79th Street Causeways. This structure has bridges near the east and west ends designed to accommodate navigation with a solid fill approximately 1.5 miles long between the bridges. Fill was obtained from a borrow pit to the north of the embankment. In places this pit is 29 feet deep. The existence of the solid fill concentrates the tidal flow along the sides of the Bay and tends to restrict circulation in the center.

The Outlook for the Future

Although the construction activities of man in the northern portion of Biscayne Bay have been so extensive that it can almost be considered as an artificial waterway, the alterations in the tidal prism and construction of inlets have been such as to improve water quality rather than detract from it. This is in contrast to areas on the Gulf Coast such as Boca Ciega Bay near Tampa where land fills have blocked the circulation. Obviously, the activities have completely altered the biological systems.

With this in mind the State Legislature enacted a law designating Biscayne Bay as an aquatic preserve. This law was signed by the Governor on 11 June 1974. Stating its intent to preserve an essentially natural condition, the law places stringent controls on future work in the bay. Thus, it is not likely that any new structures such as those described here will be build. It is likely that old structures such as the Venetian Causeway will be replaced, but only after careful scientific scrutiny so that the new structures will be an improvement over the old.

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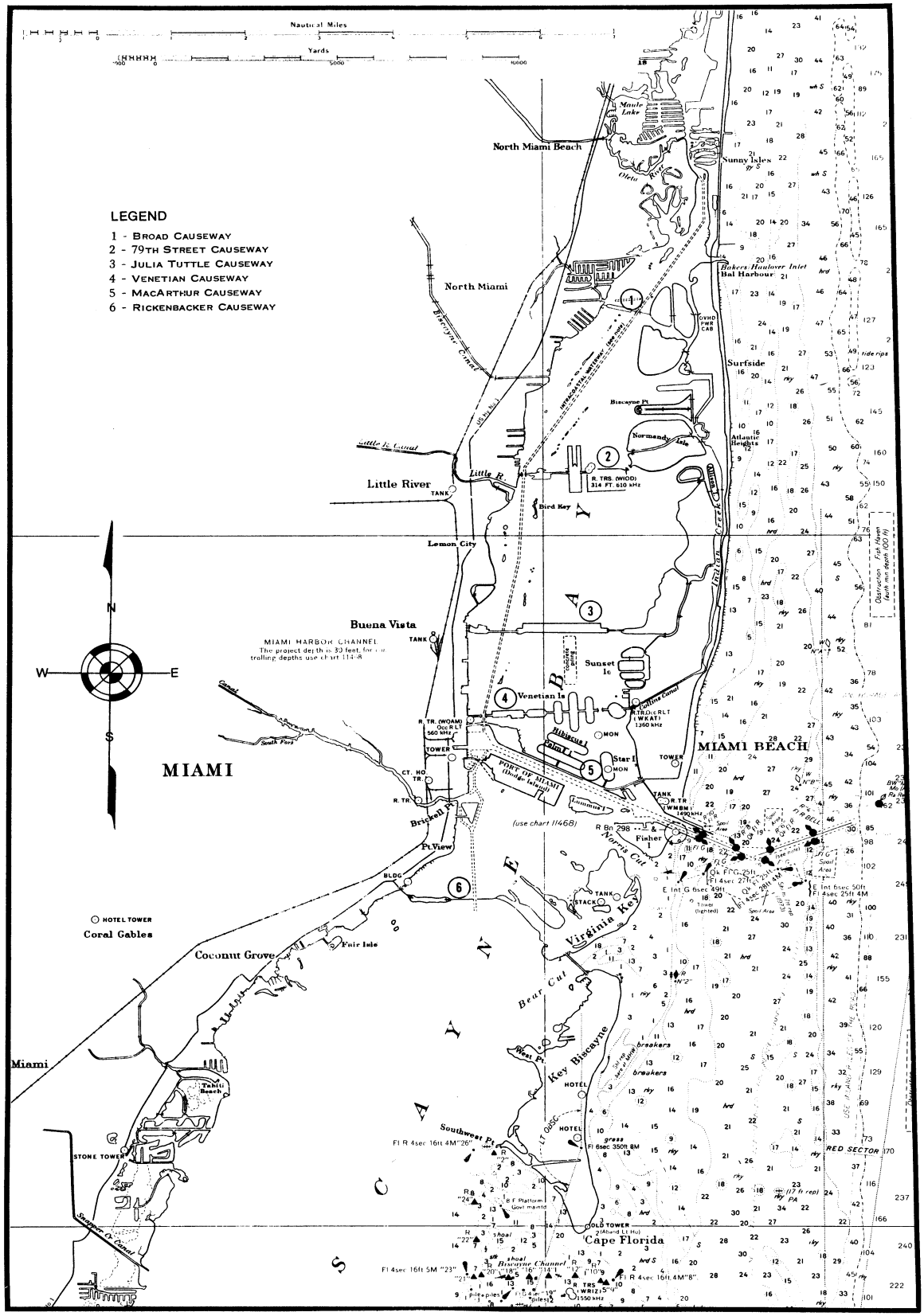

Fig. 1 Area Map (Source: Chart No. 11466, NOAA).